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Understanding the Operative Experience of the Practicing Pediatric Surgeon
Implications for Training and Maintaining Competency

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IMPORTANCE The number of practicing pediatric surgeons has increased rapidly in the past 4 decades, without a significant increase in the incidence of rare diseases specific to the field. Maintenance of competency in the index procedures for these rare diseases is essential to the future of the profession.

OBJECTIVE To describe the demographic characteristics and operative experiences of practicing pediatric surgeons using Pediatric Surgery Board recertification case log data.

DESIGN, SETTING, AND PARTICIPANTS We performed a retrospective review of 5 years of pediatric surgery certification renewal applications submitted to the Pediatric Surgery Board between 2009 and 2013. A surgeon's location was defined by population as urban, large rural, small rural, or isolated. Case log data were examined to determine case volume by category and type of procedures. Surgeons were categorized according to recertification at 10, 20, or 30 years.

MAIN OUTCOME AND MEASURE Number of index cases during the preceding year.

RESULTS Of 308 recertifying pediatric surgeons, 249 (80.8%) were men, and 143 (46.4%) were 46 to 55 years of age. Most of the pediatric surgeons (304 of 308 [98.7%]) practiced in urban areas (ie, with a population >50 000 people). All recertifying applicants were clinically active. An appendectomy was the most commonly performed procedure (with a mean [SD] number of 49.3 [35.0] procedures per year), nonoperative trauma management came in second (with 20.0 [33.0] procedures per year), and inguinal hernia repair for children younger than 6 months of age came in third (with 14.7 [13.8] procedures per year). In 6 of 10 "rare" pediatric surgery cases, the mean number of procedures was less than 2. Of 308 surgeons, 193 (62.7%) had performed a neuroblastoma resection, 170 (55.2%) a kidney tumor resection, and 123 (39.9%) an operation to treat biliary atresia or choledochal cyst in the preceding year. Laparoscopy was more frequently performed in the 10-year recertification group for Nissen fundoplication, appendectomy, splenectomy, gastrostomy/jejunostomy, orchidopexy, and cholecystectomy ($P < .05$) but not lung resection ($P = .70$). It was more frequently used by surgeons recertifying in the 10-year group (used in 11 375 of 14 456 procedures [78.7%]) than by surgeons recertifying in the 20-year (used in 6214 of 8712 procedures [71.3%]) or 30-year group (used in 2022 of 3805 procedures [53.1%]).

CONCLUSIONS AND RELEVANCE Practicing pediatric surgeons receive limited exposure to index cases after training. With regard to maintaining competency in an era in which health care outcomes have become increasingly important, these results are concerning.

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The American Board of Surgery (ABS) first approved a Certificate in Special Competency in Pediatric Surgery in 1973, leading to the first qualifying examination in 1975.[1] Since that time, there has been a persistent and necessary connection between the field of pediatric surgery and the field of general surgery. General surgery trainees are required to have a basic experience in pediatric surgery, whereas pediatric surgery trainees train for an additional 2 years to obtain experience in those specific cases that characterize the field of pediatric surgery (eg, tracheoesophageal fistula repair, congenital diaphragmatic hernia repair, and neonatal bowel resection for necrotizing enterocolitis), in order to master the care of children with complex conditions. This link to general surgery remains fundamental and critical to the successful training of pediatric surgeons. In a field where a wide spectrum of rare congenital anomalies are the expected scope of practice, knowledge and experience in specific index pediatric surgery cases is essential to ensuring competency. Imperfect as the approach may be, the specific case volume has served as a benchmark to help ensure experience, both at the general surgery trainee and pediatric surgery fellow level.

In 2012, the Association of Program Directors in Pediatric Surgery and the Residency Review Committee approved a list of minimum case numbers in 18 key operative categories for all pediatric surgery trainees. This list was also endorsed by the Pediatric Surgery component board of the ABS. However, barriers surrounding the provision of adequate experience for pediatric surgery trainees remain very real, with an increasing pool of trainees in the context of a relatively fixed number of operative cases available for training. Beyond training, many within the pediatric surgery community have expressed concerns about the ongoing experience of the practicing pediatric surgeon as it relates to rare conditions, particularly in this current era where maintaining competency, patient outcome, and safety is being increasingly scrutinized. To address this challenge, there have been discussions regarding whether pediatric surgery should further subspecialize, regionalize, or change the training curriculum and/or patient care delivery paradigm. The present study aims to provide additional data to the ongoing dialogue by describing the experiences of practicing pediatric surgeons by reviewing case log data submitted to the ABS during the recertification process.

Key Points

Question Is the operative experience of the practicing pediatric surgeon sufficient to maintain competency?

Findings In this review of 5 years of pediatric surgery certification renewal applications submitted to the Pediatric Surgery Board between 2009 and 2013, an appendectomy was the most commonly performed procedure, nonoperative trauma management came in second, and inguinal hernia repair for children younger than 6 months of age came in third.

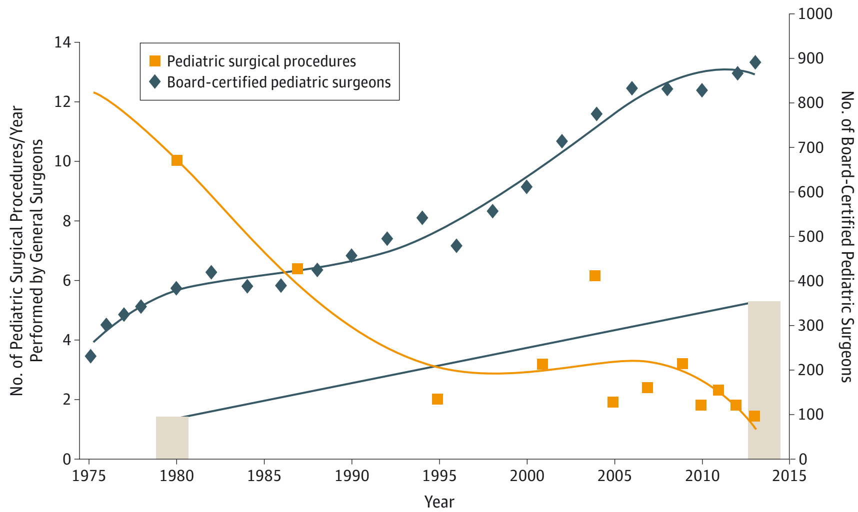
Meaning Practicing pediatric surgeons receive limited exposure to index cases after training, raising questions regarding maintenance of competency.

Methods

Information from the ABS database system was used to describe Pediatric Surgery diplomates and training programs. Recertification applications for pediatric surgery certification submitted to the Pediatric Surgery Board (PSB) from 2009 to 2013 were reviewed. Applicants include pediatric surgeons previously certified by the PSB who are seeking recertification or maintenance of certification. Data for this study were obtained from self-reported records submitted by pediatric surgeons as part of the recertification process. Clinically active diplomates must submit an operative log reflecting the most recent calendar year or 12-month period prior to application. Demographic data, data on types of practice, and medical school training data were extracted. The location of the surgeon was defined via a method similar to previous reports, in which the zip code reported on the application was used in conjunction with Rural Urban Commuting Area codes developed by the US Census Bureau. Population cutoffs for these categories include more than 50 000 people for urban location, 10 000 to 49 000 people for large rural location, 2500 to 9999 people for small rural location, and fewer than 2500 people for isolated location.[2,3] The Office of Research Integrity and Compliance institutional review board provided written documentation that this study does not meet the definition of human subjects research and thus does not require review by the institutional review board.

The number of training programs was obtained using data from the Association of Pediatric Surgery Training Program Directors from 1980 to 2013. Case mix data for general surgeons was obtained using ABS recertification data from 1980 to 2013. Diplomates either record their operative experiences directly into the ABS online log system or have the option of electronically transferring operative data from the American College of Surgeons Case Log system. The ABS operative logs are based on the Accreditation Council for Graduate Medical Education (ACGME) coding system for tracking pediatric surgery residents' operative experiences throughout their training. The ACGME/Residency Review Committee for Surgery coding system maps specific *Current Procedural Terminology* procedure codes into a smaller, more manageable list; the list currently includes 196 specific pediatric surgery procedures under 12 broad body system categories. The ABS uses ACGME procedure codes to document the operative experiences of all recertification/maintenance of certification applicants in all specialties. In addition, the PSB, in conjunction with other pediatric surgery organizations (American Pediatric Surgery Association, American Academy of Pediatrics, ABS, Residency Review Committee, and Association of Pediatric Surgery Training Program Directors), has developed a list of 21 specific "key operative cases" that are used by the Residency Review Committee for Surgery to review the operative experiences of pediatric surgery fellows; minimum training thresholds have been established for each of the 21 cases. Each of the designated case categories includes 1 to 6 specific procedures from the ACGME operative list. For this study, the operative experiences of the practicing pediatric

Figure. Data on Number of Pediatric Surgery Cases Performed by General Surgeons, Number of Board-Certified Pediatric Surgeons, and Increase in Pediatric Surgery Training Programs



surgery diplomates were also specifically reviewed for each of these designated index case categories.

For relevant operations that are routinely performed with either an open or laparoscopic/thoracoscopic approach, the proportion of each type of operation was compared between recertifying applicants at the 10-, 20-, and 30-year mark. These procedures included Nissen fundoplication, appendectomy, splenectomy, lung resection or biopsy, gastrostomy/jejunostomy, orchidopexy, and cholecystectomy. The year of recertification was assigned based on the year of initial certification and rounded to the closest decade (eg, 10-year group for ≤14 years from initial certification, 20-year group for 15-24 years, and 30-year group for ≥25 years). Differences in proportions between groups were tested using χ^2 analysis, and $P \leq .05$ was considered statistically significant.

Results

Between 1980 and 2013, the number of pediatric surgery cases performed by general surgeons decreased from 10.0 to 1.4 per surgeon per year, while the number of ACGME-approved North American pediatric surgery training programs increased from 14 to 53 (278% increase), and the number of ABS-certified pediatric surgeons increased from 383 to 889 (132% increase) (**Figure**). Data from 308 pediatric surgeons seeking PSB recertification from 2009 to 2013 were analyzed.

Of 308 recertifying pediatric surgeons, 249 (80.8%) were men, and 304 (98.7%) were located in urban areas. Almost half of these diplomates (153 [49.7%]) were practicing within a private multidisciplinary group. The number of recertifying applicants was 162 (52.6%), 96 (31.2%), and 50 (16.2%) in the 10-, 20-, and 30-year recertification groups, respectively (**Table 1**). All of the applicants who applied for recertification were clinically active and submitted operative logs for review. The mean (SD) number of pediatric surgical procedures performed was 432.7 (222.6) per surgeon (range, 4-1847 per surgeon). When categorized by organ system, the majority of procedures were abdominal (with a mean [SD] number of 135.5 [74.2] procedures per year), followed by hernia repair (74.7 [64.3] procedures per year) and cardiovascular (56.6 [43.3] procedures per year) (**Table 2**).

Among the 21 key procedures of interest, an appendectomy was the most commonly performed procedure (with a mean [SD] number of 49.3 [35.0] procedures per year), nonoperative trauma management came in second (with 20.0 [33.0] procedures per year), and inguinal hernia repair for children younger than 6 months of age came in third (with 14.7 [13.8] procedures per year). Less frequently performed procedures included a splenectomy (with a mean [SD] number of 1.2 [1.7] procedures per year), a kidney tumor resection (1.2 [1.5] procedures per year), and the surgical treatment of biliary atresia/choledochal cyst (0.9 [1.7] procedures per year). Notably, of the 308 surgeons, 185 (60.1%) reported that they had not performed an operation to treat biliary atresia/choledochal cyst in a 12-month period, whereas only 170 (55.2%) reported that they had performed at least 1 kidney tumor resection, 193 (62.7%) at least 1 neuroblastoma resection, and 178 (57.8%) at least 1 splenectomy (**Table 3**). Overall, in 6 of 10 "rare" pediatric surgery cases, the mean number of procedures performed in the previous year was less than 2.0 (Table 3).

Laparoscopy was more frequently used by surgeons recertifying in the 10-year group (used in 11 375 of 14 456 procedures [78.7%]) than by surgeons recertifying in the 20-year (used in 6214 of 8712 procedures [71.3%]) or 30-year group (used in 2022 of 3805 procedures [53.1%]). These differences were statistically significant for all procedures with the exception of lung resection. The 10-year group had the highest proportion of surgeons choosing a laparoscopic approach in all of the procedures studied, with the exception of splenectomy (used in 171 of 214 procedures [79.9%]), for which the 20-

Table 1. Demographic Characteristics of 308 Recertifying Pediatric Surgeons

Characteristic	Surgeons, No. (%) (N = 308)
Sex	
Male	249 (80.8)
Female	59 (19.2)
Age group, y	
38-45	62 (20.1)
46-55	143 (46.4)
56-65	84 (27.3)
66-75	19 (6.2)
Years since original certification	
10	162 (52.6)
20	96 (31.2)
30	50 (16.2)
Examination year	
2009	86 (27.9)
2010	22 (7.1)
2011	79 (25.6)
2012	45 (14.6)
2013	76 (24.7)
Surgeon location	
Urban	304 (98.7)
Large rural	3 (1.0)
Small rural	1 (0.3)
Isolated	0 (0.0)
Type of practice	
Private solo	10 (3.2)
Private multidisciplinary group	153 (49.7)
Government	1 (0.3)
Full-time academic	144 (46.8)
Medical school training	
United States	294 (95.5)
International medical graduate	14 (4.5)

year group had a slightly higher rate of use (used in 96 of 116 procedures [82.8%]), although this did not reach statistical significance. In 7 of the 8 procedures analyzed, there was a statistically significant difference in the proportion of laparoscopic procedures between the 3 groups (**Table 4**). Thoracoscopic lung resection was not found to have a significant difference (P = .70); however, this code was not introduced to the PSB database until 2013 and thus has an overall lower number for comparison.

Discussion

The present study describes the scope of operations of practicing pediatric surgeons in the United States and provides a unique insight into the practice profile of the pediatric surgeon. Data presented include index procedures that, though rarely performed, are defining elements for the field of pediatric surgery. These results are particularly important as the pediatric surgery community continues to grapple with the issue of maintaining competency in performing these complex cases because they are performed infrequently. While the number of training programs remained relatively restricted throughout the 1990s, the last decade and a half has seen a continued increase in surgical training programs with now more than 46 training programs active in the United States today. Thus, while some practices report a shortage of practicing pediatric surgeons, these shortages are likely specific to certain locations. The increased demand for pediatric surgeons has occurred concurrent with a shift in the more common pediatric surgery cases from general surgeons to pediatric surgeons. However, this has occurred in the context of a stable national rate of births and associated rare anomalies. Thus, the number of rare index cases performed by each individual pediatric surgeon has decreased such that maintaining competency becomes an even greater concern.[4]

Table 2. Data on Categories of Procedures From 2009 to 2013

Procedure	No. of Procedures/y	
	Mean (SD)	Median (IQR)
Skin/soft tissue/musculoskeletal	37.1 (45.1)	21 (7-52)
Head and neck	12.9 (12.8)	10 (4-18)
Thoracic	15.8 (14.2)	12 (5-22)
Diaphragm	2.5 (2.8)	2 (0-4)
Cardiovascular	56.6 (43.3)	46 (26-78)
Abdominal	135.5 (74.2)	126 (84-185)
Hernia repair	74.7 (64.3)	65 (40-97)
Liver/biliary	16.0 (12.7)	13 (7-22)
Genitourinary	33.2 (51.4)	19 (9-39)
Endoscopic	14.5 (14.2)	11 (4-21)
Trauma	20.0 (33.0)	6 (0-27)
Total	432.7 (222.6)	400 (272-583)

Abbreviation: IQR, interquartile range.

The majority of volume-outcome studies in pediatric surgery have centered on analysis of hospital-level volume rather than surgeon volume. Surgeon-volume outcome comparisons in complex pediatric procedures are difficult to study owing to the rarity of the diseases and the difficulty in achieving appropriate statistical power. McAteer et al[5] concluded that hospital-level factors are often strongly associated with better outcomes in rare complex problems such as congenital diaphragmatic hernia and cardiac surgery, while surgeon-level characteristics are relevant for less resource-demanding operations such as appendectomy and pyloromyotomy.[5]

A standardized list of index cases for which the pediatric surgeon should display competency was first defined by Ravitch and Barton[6] in 1974 and comprised esophageal atresia/tracheoesophageal fistula, congenital diaphragmatic hernia, intestinal atresia, gastroschisis/omphalocele, imperforate anus, Hirschsprung disease, neuroblastoma, nephroblastoma, and rhabdomyosarcoma. Using the Kid's Inpatient Database, Fonkalsrud et al[4] found that, in 2010, pediatric surgeons were performing an average of 9.5 index procedures per surgeon per year, with an average of 11.3 index procedures per surgeon per year at their institution, which is a decrease from an estimated average of 18.0 index procedures per surgeon in 1970.

Table 3. Pediatric Surgery Board Key Operative Cases From 2009 to 2013

Index Case	No. of Procedures/y Mean (SD)	Median (IQR)	Maximum	% of Pediatric Surgeons With 0 Cases
Appendectomy	49.3 (35.0)	42 (25-65)	257	4
Nonoperative trauma management	20.0 (33.0)	6 (0-27)	221	42
Inguinal hernia repair for child <6 mo of age	14.7 (13.8)	11 (6-20)	106	5
Pyloric stenosis	11.1 (9.2)	9 (4-16)	52	8
Bronchoscopy/esophagoscopy	10.1 (11.1)	7 (2-15)	65	19
GE reflux (fundoplication)	8.7 (9.6)	6 (2-12)	56	13
Cryptorchid testis	6.5 (9.7)	4 (2-8)	114	15
Head/neck operations	6.0 (7.8)	4 (1-7)	68	19
Malrotation/intussusception	4.3 (3.4)	4 (2-6)	25	11
Abdominal wall defect closure	4.3 (4.3)	3 (1-6)	30	18
Intestinal atresia/duodenal atresia	3.0 (3.8)	2 (1-4)	36	22
Anorectal malformation	2.2 (2.8)	2 (0-3)	30	29
Adnexal operations	2.2 (2.8)	2 (0-3)	25	32
Neuroblastoma resection	2.1 (2.9)	1 (0-3)	32	37
Lung resection	1.9 (2.5)	1 (0-3)	25	39
Hirschsprung disease (pull through)	1.7 (2.7)	1 (0-2)	40	32
Congenital diaphragmatic hernia repair	1.6 (1.9)	1 (0-2)	13	35
Esophageal atresia/TE fistula	1.5 (1.7)	1 (0-3)	8	39
Spleen operations	1.2 (1.7)	1 (0-2)	17	42
Kidney tumor resection	1.2 (1.5)	1 (0-2)	9	45
Biliary atresia/choledochal cyst	0.9 (1.7)	0 (0-1)	14	60

Abbreviations: GE, gastroesophageal; IQR, interquartile range; TE, tracheoesophageal.

Table 4. Data on Laparoscopic vs Open Approach

Procedure	No. (%) of Procedures Performed: 10-y Group (162 Surgeons) Laparoscopic	10-y Group Open	20-y Group (96 Surgeons) Laparoscopic	20-y Group Open	30-y Group (50 Surgeons) Laparoscopic	30-y Group Open	*P* Value
Fundoplication	1129 (69.3)	500 (30.7)	405 (50.5)	397 (49.5)	62 (24.2)	194 (75.8)	<.001
Appendectomy	7268 (90.6)	752 (9.4)	4273 (86.5)	666 (13.5)	1415 (63.5)	813 (36.5)	<.001
Splenectomy	171 (79.9)	43 (20.1)	96 (82.8)	20 (17.2)	22 (47.8)	24 (52.2)	<.001
Lung resection[a]	32 (45.1)	39 (54.9)	18 (43.9)	23 (56.1)	2 (28.6)	5 (71.4)	.70
Lung biopsy[a,b]	211 (74.3)	73 (25.7)	85 (63.9)	48 (36.1)	17 (48.6)	18 (51.4)	.002
Gastrostomy/jejunostomy	1058 (56.5)	816 (43.5)	495 (39.1)	770 (60.9)	164 (36.3)	288 (63.7)	<.001
Orchidopexy	101 (11.8)	755 (88.2)	40 (7.4)	502 (92.6)	10 (2.5)	396 (97.5)	<.001
Cholecystectomy	1405 (93.2)	103 (6.8)	802 (91.8)	72 (8.2)	330 (88.0)	45 (12.)	.004

[a] Thoracoscopic.

[b] Only 2013 data available for thoracoscopic pulmonary resection (37 surgeons in the 10-year group, 31 surgeons in the 20-year group, and 8 surgeons in the 20-year group).

Using a similar definition (with the exclusion of rhabdomyosarcoma), we find the mean rate of index cases to be 17.6 procedures per surgeon per year. The difference in procedure rates is likely multifactorial; however, this higher rate does seem to more closely approximate the current national rate, which is consistent with overall trends in national surgery case volumes.

A notable finding was that, for biliary atresia, splenectomy, kidney tumor resection, and nonoperative trauma management, 60%, 42%, 45%, and 42% of recertifying surgeons, respectively, reported 0 cases in their operative log. In addition, of the PSB key operative cases for which pediatric surgery trainees should gain adequate exposure, we found the mean total rate of these cases among practicing pediatric surgeons to be 154.5 per surgeon per year (Table 3) and 432.7 per surgeon per year for all cases (Table 2).

A potential option to augment the dearth of operative PSB index cases is simulation-based education for practicing pediatric surgeons. Simulation-based education focuses on the cognitive and technical aspects of a particular disease model and provides a method for trainees and surgeons to refine skills. Surgical trainees participating in simulation-based education have demonstrated improvements in operative time, technical skill assessments, and patient-centered outcomes.[7-13] Although the majority of research has focused on simulation-based education for surgical trainees, practicing pediatric surgeons may also benefit from this educational tool.

Another approach the field will need to consider is the further subspecialization of pediatric surgeons. This has already occurred on some level at larger children's centers, where pediatric surgeons have developed subspecialty areas of expertise, and will certainly help address the issues of technical competency and will help facilitate the more-frequent performance of rare cases. This also will have implications on the broader field of pediatric surgery in terms of what the definition and scope of practice of a pediatric surgeon will be.

The urban concentration of pediatric surgeons continues to be significant and may place large portions of US children at risk. Nakayama et al[14] noted that the shortage of pediatric surgeons in the United States is primarily a problem of number and distribution. They identified multiple dense geographical areas with no pediatric surgical support, while there were smaller and less-populated regions with at least 1 practicing pediatric surgeon.[14] Of the 308 recertifying pediatric surgeons in our study, 304 (98.7%) practiced in urban areas; however, our definition of urban includes a very low population threshold (>50 000 people), and only 4 of the 308 diplomates were located in areas with fewer than 50 000 people. Because only approximately 1% of recertifying pediatric surgeons practiced in rural areas, no meaningful calculations could be performed comparing operative experiences. Difficult access to a practicing pediatric surgeon could translate into significant harm to patients, especially because the rate of exposure to pediatric surgical cases in general surgery training programs is decreasing. According to ACGME case logs from graduating general surgery residents, the mean (SD) number of pediatric procedures performed per resident during training is 33.8 (17.6), and of these, the mean (SD) number of herniorrhaphies performed is 18.5 (10.3).[15]

We identified a significant difference in the proportion of laparoscopic procedures performed between the 3 recertifying groups (Table 4). For cholecystectomy, for which the outcome benefits of laparoscopy are clear,[16] the difference between the 10-year group (1405 of 1508 procedures used laparoscopy [93.2%]) and the 30-year group (330 of 375 procedures used laparoscopy [88.0%]) was 5.2%; for procedures such as Nissen fundoplication, for which randomized trials have not shown the superiority of laparoscopy,[17,18] the difference between the 10-year group (1129 of 1629 procedures used laparoscopy [69.3%]) and the 30-year group (62 of 256 procedures used laparoscopy [24.2%]) was 45.1%. The data suggest that surgeons who have been in practice longer and were trained before the advent of laparoscopic surgery remain cautious in introducing minimally invasive surgery into their practice until the evidence shows clear benefits for the laparoscopic approach.

Our study has several limitations that need to be considered. First, the data used for the analysis come from physician self-reporting. The PSB relies on a surgeon to accurately report his or her procedures, but there may be instances in which the reported operative logs are biased or not fully representative of that individual surgeon's practice. Second, the PSB recertification applicants represent a sample of practicing pediatric surgeons who may have unique characteristics that do not accurately represent the true pediatric surgical workforce, therefore leading to potential selection bias. We believe, however, that this is minimal because, in 2009, the estimated US pediatric surgical workforce consisted of 1150 surgeons, and there were exactly 1130 PSB-certified surgeons in 2010.[4,14]

Conclusions

Our study provides a general view of the scope of operations that practicing pediatric surgeons are performing in the United States and raises important questions about maintaining competency in an era when the increase in the number of pediatric surgeons in the workforce far exceeds the increase in the number of complex surgical problems that they are responsible for treating, which has potential repercussions on the competency of future pediatric surgeons.

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